CLAIMS

What is claimed is:

1. A vibration detector and transducer, comprising:

a light source for emitting light signals;

a light detector for receiving light signals emitted from the optical source and converting the received light signals to electrical signals; and

an array of optical waveguide resonators positioned between the light source and the light detector, each resonator being positioned to receive vibration waves and each resonator having a different resonant frequency such that each resonator will modulate the intensity of the light passing between the optical source and the light detector in response to the vibrations received by the resonator.

2. A vibration detector and transducer according to Claim 1, wherein the vibration waves comprise acoustic waves.

3. A vibration detector and transducer according to Claim 1, wherein the vibration waves comprises seismic waves.

4. A vibration detector and transducer according to claim 1, wherein each of the resonators comprises a cantilever having a predetermined length, and wherein the resonant frequency of the resonator is proportional to both geometric and physical properties of the cantilever.

5. A vibration detector and transducer according to claim 1, wherein each resonator comprises a polymeric material.

6. A vibration detector and transducer according to claim 1, wherein each resonator has a Q-factor lower than the Q-factor of an identically configured and dimensioned resonator formed of silicon.

7. A vibration detector and transducer according to claim 1, wherein each resonator comprises a material having a Young's Modulus lower than the Young's Modulus of silicon.

8. A vibration detector and transducer according to claim 5, wherein the material has a Young's Modulus of about 4.4GPa.

9. A vibration detector and transducer according to claim 1, wherein the vibration detector and transducer is sized and configured to be implanted in a human ear.

10. A vibration detector and transducer according to claim 9, wherein the vibration detector and transducer is sized and configured to be implanted in the middle ear of a human.

11. A vibration detector and transducer according to claim 1, wherein the light source comprises an LED array.

12. A vibration detector and transducer according to claim 1, wherein the light detector comprises a photodiode array.

13. A vibration detector and transducer according to claim 1, further comprising an acoustic housing surrounding the light source, the light detector, and the oprical waveguide resonators, the housing being configured to isolate ambient vibrations from airborne vibrations.

14. An apparatus for enhancing hearing in a human or veterinary patient, said apparatus comprising:

a light source for emitting light signals;

a light detector for receiving light signals emitted from the optical source and converting the received light signals to electrical signals;

an array of optical waveguide resonators positioned between the light source and the light detector, each resonator being positioned to receive sound and each resonator having a different resonant frequency such that each resonator will modulate the intensity of the light passing between the optical source and the light detector in relation to the sound received by the resonator;

a housing encasing at least one of the light source, the light detector and the array of optical waveguide resonators, the housing being configured to be worn on or in the body of the patient.

15. An apparatus according to claim 14, wherein each of the resonators comprises a cantilever having a predetermined length, and wherein the resonant frequency of the resonator is proportional to both geometric and physical properties of the cantilever.

16. An apparatus according to claim 14, wherein each resonator comprises a polymeric material.

17. An apparatus according to claim 14, wherein each resonator has a Q-factor lower than the Q-factor of an identically dimensioned resonator formed of silicon.

18. An apparatus according to claim 14, wherein each resonator is formed of a material having a Young's Modulus lower than the Young's Modulus of silicon.

19. An apparatus according to claim 18, wherein the material has a Young's Modulus of about 4.4GPa.

20. An apparatus according to claim 14, wherein the light source, the light detector and the array of optical waveguide resonators are encased in the housing, and wherein the housing is sized and configured to be implanted in the ear.

21. An apparatus according to claim 14, wherein the light source comprises an LED.

22. An apparatus according to claim 14, wherein the light detector comprises a photodiode array.

23. An apparatus according to claim 14, wherein the housing is configured to isolate ambient vibrations from airborne sound.

24. An apparatus according to claim 14 , wherein the light source, the light detector and the array of optical waveguide resonators are formed on a silicon microchip.

25. A method of detecting vibrations and converting the vibrations into electrical signals, the method comprising:

providing a plurality of optical waveguide resonators, each having a different resonant frequency;

causing the optical waveguide resonators to receive an incoming vibration wave;

directing light through the resonators, such that the light is modulated by vibration of at least one of the resonators;

receiving the modulated light; and

converting the modulated light into electrical signals.

26. A method according to claim 25, wherein the step of providing a plurality of optical waveguide resonators comprises placing the resonators in an acoustically optimum orientation relative to the incoming vibration wave.

27. A method according to Claim 25 wherein the step of providing a plurality of optical waveguide resonators comprises positioning the resonators in a substantially perpendicular orientation relative to the incoming vibration wave.

28. A method according to Claim 25, wherein the wave is an acoustic wave.

29. A method according to Claim 25, wherein the wave is a seismic wave.

30. A method for treating hearing loss or impairment in a human or veterinary patient, the method comprising the steps of:

providing a hearing enhancement device including

a light source for emitting light signals;

a light detector for receiving light signals emitted from the optical source and converting the received light signals to electrical signals; and

an array of optical waveguide resonators positioned between the light source and the light detector, each resonator being positioned to receive sounds and each resonator having a different resonant frequency such that each resonator will modulate the intensity of the light passing between the optical source and the light detector in response to the sounds received by the resonator; and

providing an interface between the hearing enhancement device and the inner ear of the patient.

31. A method according to Claim 30, wherein the photodetector includes electronic circuitry for converting light signals into electrical signals, the circuitry having variable gains and means for adjusting the gains, and further comprising the steps of:

testing the patient's hearing after interface between the device and the inner ear has been made; and

adjusting the gains to optimize the patient's hearing.

32. A method according to Claim 30, wherein the hearing enhancement device comprises a hearing aid worn by the patient, and wherein the step of providing an interface comprises transmitting the electrical signals from the light detector to a speaker in the hearing aid.

33. A method according to Claim 30, wherein the step of providing an interface comprises implanting an electrode in proximity to the patient's auditory nerve, and driving the electrode with the electrical signals from the light detector to stimulate the patient's auditory nerve, resulting in perceptible sound to the patient.

34. A method according to Claim 32, wherein the step of providing an interface further comprises a step of placing at least a portion of the hearing enhancement device in the patient's ear canal.

35. A method according to Claim 34, wherein the step of placing at least a portion of the device in the patient's ear canal comprises placing the entire hearing enhancement device in the patient's ear canal.

36. A method according to Claim 34, wherein the step of placing at least a portion of the device in the patient's ear canal comprises positioning the device such that the resonators extend substantially perpendicular to the ear canal.

37. A method according Claim 30, wherein the step of providing an interface comprises implanting at least a portion of the hearing enhancement device in the patient's body.

38. A method according to Claim 30, wherein the step of providing an interface comprises implanting at least a portion of the hearing enhancement device in the patient's middle ear.

39. A method according to Claim 38, wherein the step of implanting at least a portion of the hearing enhancement device in the patient's middle ear comprises implanting the entire hearing enhancement device in the patient's middle ear.

40. A method according to Claim 38, wherein the step of implanting at least a portion of the hearing enhancement device in the patient's middle ear comprises positioning the device such that the resonators extend substantially perpendicular to the patient's tympanum.

41. A method according to Claim 31, wherein the circuitry includes RF interface, and wherein:

the step of implanting at least a portion of the hearing device comprises implanting an RF receiver in the patient's body; and

the step of adjusting the gains comprises adjusting the gains using an RF transmitter located outside the body.

42. A method of making a hearing enhancement device, comprising the steps of:

providing an LED array, a photodiode array, and an optical waveguide resonator array, the resonator array being configured to receive sound from an external source and being positioned between the LED array and the photodiode array so as to modulate light transmitted from the LED array and the photodiode array in response to the received sound; and

packaging the arrays in a housing configured to be worn in or on the body of a patient.

43. A method according to Claim 42, wherein the step of packaging comprises encasing the arrays in a housing sized and configured to fit within the patient's ear canal.

44. A method according to Claim 42, wherein the step of packaging comprises encasing the arrays in a housing sized and configured to fit within the patient's middle ear.

45. A method according to Claim 42, wherein the step of packaging comprises encasing the arrays in an acoustic housing configured to isolate ambient vibrations from airborne sound.

46. A method according to Claim 42, further comprising a step of providing a power source for driving the device.

47. A method according to Claim 46, wherein the power source comprises a battery.

48. A method according to Claim 42, wherein the step of packaging comprises:

providing a first housing for the arrays and a second housing for the battery; and

coupling the first housing to the second housing.

49. A method according to Claim 42, wherein the step of providing comprises:

fabricating a silicon microelectronic chip including an LED array, a photodiode array, and circuitry for converting light signals into electrical signals;

forming a cavity in the chip; and

forming the optical waveguide resonator array over the cavity.

50. A method according to Claim 49, wherein the step of forming the optical waveguide resonator array comprises:

laminating a layer of transparent polymer material to the chip; and

removing portions of the polymer material to create a plurality of cantilevers.

51. A method according to Claim 50, wherein the step of removing portions of the polymer material comprises ablating the polymer material using laser energy.

52. A method according to Claim 50, wherein the polymer material comprises an epoxy material.

53. A method according to Claim 43, wherein the step of packaging comprises encasing the arrays in a housing configured maintain the arrays in a position substantially perpendicular to the ear canal when the device is inserted in the canal.

54. A method according to Claim 44, wherein the step of packaging comprises encasing the arrays in a housing configured maintain the arrays in a position substantially perpendicular to the patient's tympanic membrane when the device is implanted in the middle ear.